Solar Surfing

Completed Technology Project (2017 - 2018)

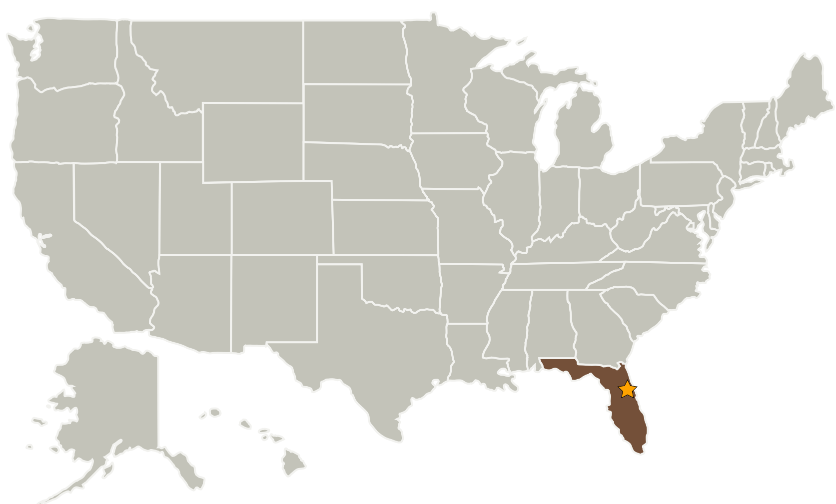
Project Introduction

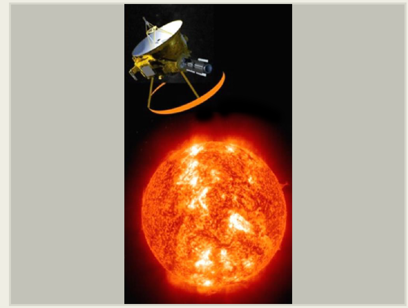
We propose to develop a novel high temperature coating that will reflect up to 99.9 % of the Sun's total irradiance, roughly a factor of 80 times better than the current state-of-the-art. This will be accomplished by leveraging off of our low temperature coating, currently being developed under NIAC funding. We will modify our existing models to determine an optimal high temperature solar reflector, predict its performance, and construct a prototype version of this coating. This prototype will be sent to our partner at the Johns Hopkins Applied Physics Laboratory where it will be tested in an 11 times solar simulator. The results of this modeling/testing will be used to design a mission to the Sun, where we hope to come to within one solar radius of the Sun's surface, 8 times closer than the closest distance planned for the upcoming Solar Probe Plus. This project will substantially advance the current capabilities of solar thermal protection systems, not only potentially allowing Solar Surfing, but allowing better thermal control of a future mission to Mercury.

Anticipated Benefits

This project will substantially advance the current capabilities of solar thermal protection systems, not only potentially allowing "Solar Surfing", but allowing better thermal control of a future mission to Mercury.

Primary U.S. Work Locations and Key Partners





Solar Surfing Credits: Robert Youngquist

Table of Contents

Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Supporting Organization	R&D Center	Laurel, Maryland

Primary U.S. Work Locations
Florida

Project Transitions

April 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

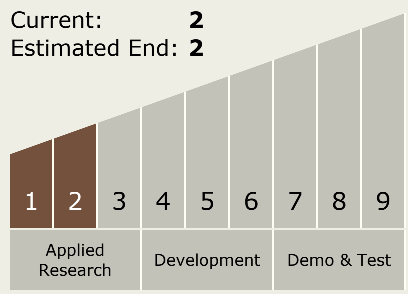
Eric A Eberly

Principal Investigator:

Robert C Youngquist

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



January 2018: Closed out

Closeout Summary: The Sun sustains life on Earth and NASA has made its study one of the four pillars of the Science Mission Directorate. A specific area of study, the coronal heating problem, has been of significant concern for nearly 80 years; namely how does the 5800 K surface of the Sun heat the nearby corona to over 1,000,000 K. Differing theories have been proposed to explain this process, but verification by actual measurement would not only resolve this issue, it would provide close-up measurements of the Sun never before obtained. However, this requires the development of a solar shield that can protect a satellite located less than 10,000 km from the Sun's surface. Steps towards that capability are the goal of this NIAC project. The current state-of-the-art in solar shielding is best shown by the upcoming Parker Solar Probe Mission, so the approach taken by that satellite is discussed and used as a starting point; allowing a distance of 9.5 solar radii from the Sun's center to be reached. It is then shown that state-of-the-art solar reflectors do not improve this performance. Next, we review the use of pressed powder as a better solar reflector and show that there is some improvement, but not sufficient to reach the Sun's surface. We spend some time on this architecture because the Parker Solar Probe has a thin scattering layer on its solar shield and it is important to discuss the advantages and disadvantages of this feature. A key concept that allows a spacecraft to come to within 1 Solar radii of the Sun's surface is to let the infrared radiation generated by the shield be emitted from the back side of the shield and then use a silvered plastic to reflect that infrared radiation away from the spacecraft. This allows the front of the solar shield to scatter away most of the Sun's power, i.e. low emissivity, while allowing the back side to emit most of the absorbed energy, i.e. high emissivity. But now another problem arises; up to this point the shield was assumed to be a flat sheet, however as the vehicle gets close to the Sun a flat shield is not sufficient to protect the spacecraft. A curved shield is needed to block the nearly 2π steradians of solar exposure and this curvature reduces the infrared emission from the back of the vehicle, causing a temperature rise. Modelling with a solar shield coated with BaF_2 shows that the nearest approach distance to the Sun's surface is about 0.6 Solar Radii before shield degradation, vehicle heat load, and the need for shield curvature all combine to prevent closer approach. However, through the use of possible new materials and a transient fly-by analysis the transition region might still be reached, but that analysis needs to wait for a future project. As part of this NIAC project we developed relatively large (3-inch diameter) samples of our powder based solar reflectors. We had planned on sending these to the Johns Hopkins University Applied Physics Laboratory for high intensity radiative testing, but due to contractual issues this did not happen. However, in the development and aftermath of creating these large samples we significantly advanced the performance and attributes of our high reflectivity coating. In addition, we developed a connection with the Parker Solar Probe Team, which led to Mark Hasegawa, a thermal engineer at Goddard, becoming involved in the project. Dr. Hasegawa is sending a set of coatings to the International Space Station (ISS) for long term exposure testing and he gave up a spot so that our new coating could be included in this Low-Earth Orbit environmental test. We have not achieved a design that can reach the surface of the Sun, but we have a design that should allow much closer approach than with the current state-of-the-art (by about a factor of 8). We also were not able to arrange for high irradiance testing, but instead have made substantial advance in the performance of our coating and we have a sample going to the International Space Station. Finally, JPL learned of this work and believe that it is potentially an enabling technology advance allowing future spacecraft to reach interstellar space in under 40 years by allowin

Technology Areas

Primary:

- TX14 Thermal Management Systems
  - └ TX14.1 Cryogenic Systems
    - └ TX14.1.1 In-space Propellant Storage & Utilization

Target Destination

The Sun

Images

Project Image
Solar Surfing Credits: Robert Youngquist
(https://techport.nasa.gov/image/102086)

Links

NASA.gov Feature Article
(https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Solar_Surfing)